MODULAR WEAPON SYSTEMS AND INSERTABLE NUCLEAR COMPONENTS

A Compendium of Requirements, Technology, Applications, and Utility (U)

by

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ABSTRACT (U)

This document is to serve as an essential first reference in determining the applicability and utility of modular nuclear weapons, including insertable nuclear components. Potential requirements for modular weapons were identified, past studies were reviewed, and warhead technologies needed to support weapons development were examined. The most promising of the potential applications of modular technology were evaluated in a utility analysis that covered survivability, safety, security, operational effectiveness, logistics, and costs. These analyses indicated potential utility of certain tactical modular applications. Recommendations are made that support continued Los Alamos development work.

CHAPTER I

INTRODUCTION

A. Purpose

The purpose of this study is to identify potential requirements for modular nuclear weapons, to review the technology needed to support modular weapons development, and to determine the feasibility, advantages, and disadvantages of developing and deploying one or more generic modular weapons in support of identified service missions.

B. Scope

The scope of this study includes:

- Defining modularity and various system configurations that constitute modularity and other pertinent terms required for understanding the subject area and this study (Chapter I and Glossary).
- Reviewing previous and on-going studies that address modularity and identifying the potential sources of requirements for development and deployment of modular weapons (Chapter II).
- Reviewing modular technology to include the advantages and disadvantages of implementation of the technology (Chapter III).
- Identifying potential applications of modular technology in terms of generic systems and applicable missions (Chapter IV).
- Evaluating potential applications in terms of operational effectiveness: safety, security, and survivability (S^3); design limitations; and cost effectiveness (Chapter V).
- Reviewing publications and regulations that affect the development and deployment of modular weapons (Chapter VI).

C. Objective

The objective of this study is to bring together in one comprehensive document the previous and current work that has been accomplished in the area of nuclear weapon modularity, to evaluate modular technology applications to the missions and requirements of the armed services, and to determine the political and regulatory restrictions that apply. It is intended that this document will serve as an essential first reference in determining whether modular technology for future weapons should be pursued, identifying weapon types and missions that might use modular technology, and postulating the political and regulatory restrictions that must be overcome.

D. Definition of Terms

Many terms have been used to define the concepts associated with weapons that have alternative warheads or require procedures to ready a complete warhead. In this study, we attempt to establish a set of distinct terms that define the entire spectrum of modularity concepts used here. Other terms used in the study are listed in the glossary.

Modularity - A nuclear weapon design concept that includes insertable nuclear components (INCs), convertible nuclear weapons, and nuclear-only INC weapons.

INC Weapon - A nuclear weapon design concept whereby a nuclear capable warhead can be converted from a nuclear-inert to a live nuclear warhead by inserting a nuclear component. There are two general subclasses of INC warheads: convertible warheads and nuclear-only warheads.

Convertible INC Weapon - An INC weapon that has both a nuclear capability when the special nuclear material (SNM) is emplaced, and a valid conventional or chemical capability when the SNM is removed.

Nuclear-Only INC Weapon - An INC weapon that has only a nuclear capability. It is not designed to have a valid conventional capability when the SNM is removed.

From the definitions above we see that there are two subclasses of INC warheads: (1) convertible warheads and (2) nuclear-only warheads. A convertible warhead is basically a conventional high-explosive (HE) warhead modified so a nuclear assembly, generally called an INC, can be inserted to give the weapon an optional nuclear yield. Convertible warheads may thus have either a nuclear yield or a useful conventional HE yield. With this option, the field commander can choose the yield (either nuclear or conventional) best suited to the delivery system, the battlefield conditions, and the target. Convertible INC designs may make many training and operational requirements cheaper and simpler because the user need concern himself with just one basic weapon system instead of two. The nuclear-only INC design is used only with a nuclear yield. With either type, the nuclear assembly (the INC) is stored away from the basic weapon most of the time. The INC is inserted only after National Command Authority (NCA) release and, ideally, only after a target is at hand. During almost all the stockpile-to-target sequence (STS), the user does not have a nuclear weapon and thus has no nuclear safety problem, thereby avoiding many problems associated with maintaining, handling, transporting, and guarding nuclear weapons.

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[redacted]

During the same time frame, gun-assembled (GA) weapons were deployed. Figure III-2 shows a cutaway of the Mk 33 8-in. projectile, which is still deployed in large stockpile numbers. [redacted]

DOD

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C. Benefits of Early IFI and GA Weapons

The IFI weapon bodies were flown on alert and there were accidents that involved scatter of SNM. Without delving into details, the IFI designs prevented large-scale health hazards or loss of life because of the separation of the INC from the remainder of the bomb body. The results from an air crash involving an IFI weapon were: loss of life and aircraft, intact survival of

[redacted]

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the secondary (if there was one), and scattered uranium at barely detectable levels if an HE explosion or fire occurred. The nature of ionizing radiation allows one to conclude that if it is not detectable with modern instruments, then it is not hazardous to life. Uranium has very feeble radioactivity: 4.5×10^9 year half-life for ^{238}U and 0.71×10^9 year half-life for ^{235}U. In order to put into perspective the hazard of uranium scatter, we note that commercial airliners use depleted uranium as a counterweight material for control surfaces; a Boeing 747 uses about 500 lb of ^{238}U. Unfortunately, airliners crash and burn and sometimes scatter ^{238}U. Whether society is aware of it or not, it has accepted the (infinitesimal) peril of uranium scatter.

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D. Disadvantages of Early IFI and GA Weapons

The IFI weapons were fielded with increasingly complex mechanisms for effecting in-flight insertion. During alert flights, the real bomb bodies were mated with the cores, and the Air Force literally wore them out. Many of the IFI bombs required a weapons officer in the bomb bay. As modern aircraft were developed, the presence of a man in the bomb bay became impossible.

The GA weapons were supplied with trainer weapon bodies as well as mock-up oralloy. The still-in-service W33 is assembled from the ground up in the field. A special truck with an officer and two specialists are required to assemble an 8-in. weapon. Couple this with the need for a cordon of guards and one has an awkward logistical problem. A highly proficient team can assemble an 8-in. weapon in 45 min; then they handcarry the assembled weapon to the nearby 8-in. howitzer.

E. Sealed-Pit Technology

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The convenience of the all-up round without having to assemble the hardware is very attractive to the military.

The first sealed-pit weapons entered service in 1958, causing production of IFI weapons to cease. The safety crisis came in early 1966 with the accident at Palomares, Spain. A B-52 bomber on airborne alert collided with a KC-135 during a routine refueling operation. Four B28 weapons either fell out or were jettisoned from the falling bomber. One of the bombs fell into the Mediterranean Sea and was recovered relatively intact after about two months. Another soft-landed on the ground because the parachute deployed. The HE of one of the other B28s that hit the ground deflagrated, and the HE of the last one detonated. There was no nuclear excursion from either of the last two, but the plutonium was scattered around the area. Plutonium is pyrophoric, and if it is heated in the presence of air, it will burn and form an aerosol of plutonium oxide. Plutonium ingested through breathing or cuts is a very serious health hazard.

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Several acres of topsoil were scooped into barrels and buried at the Savannah River site in South Carolina.

About two years later in early 1968, another airborne-alert B-52 caught fire. The pilot dropped the crew by parachute and then rode the airplane down to a burning crash on an ice floe in North Star Bay, Greenland. The contaminated iceberg was cleaned up at greater cost than the contamination at Palomares. As a result of these accidents, the U.S. stopped flying alert bombers. Work to prevent future Palomares- and Thule-type accidents continues. One important result is the introduction of IHEs. [redacted] However, IHE is extremely insensitive and provides much greater safety. A modern, high-performance, nuclear weapon primary with IHE weighs considerably more than similar technology with the HMX-based explosive. Although many new tactical weapons (except the AFAPs) are being designed with IHE, there is no hint that alert bombers will take to the air with IHE bombs on a routine basis.

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The use of IHE and Cat F PAL (see Cat F PAL in Section F.1.a below) in modern weapons is increasing. These features undeniably increase safety but can result in decreased weapon effectiveness. That is, for a given weight, volume, or SNM usage, the yield may be less. The INC, or modular, weapon can fulfill safety requirements for reduced plutonium scatter without IHE and can protect the separate, vital weapon components without a Cat F PAL built into the weapon. For these reasons, the INC may be a more attractive alternative than the ever more complicated all-up weapon.

F. Current Concepts for Modular Weapons

1. Modern Weapon Systems Architecture. Essentially all nuclear weapons can be considered to be "insertable" in a sense. The B61 is a full-fuzing-option tactical bomb. [redacted] Another example of a weapon that could be considered insertable is the Pershing missile. It has a removable warhead section that is stored separately from the missile. The warhead will not function unless it is mated to the missile and properly launched. Or as a final insertable example, an

DOE b(3)

AFAP will not operate unless it is properly fired from a howitzer. But while these systems are modular in this sense, they are not truly INCs according to the definition in Chapter I.

a. Cat F PAL. A new feature included in many modern nuclear weapons is the Cat F PAL. This is a feature built into the weapon to protect it from unauthorized use. [redacted]

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b. Emergency Destructs (EDs). The DoD also has developed Standard Operating Procedures (SOPs) for emergency destructs. [redacted]

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2. Recent Separable Component Concepts.

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a. [redacted] Figure III-3 shows the convertible concept offered by Los Alamos for the [redacted] With only a trivial reduction in HE [redacted]

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[redacted]

DOE b(3) DOE

Fig. III-3. Los Alamos Harpoon Proposal 3A warhead.

CHAPTER IV

POTENTIAL APPLICATIONS OF MODULAR TECHNOLOGY

A. General

The objectives of modular technology are to increase the military utility of applicable weapon systems with minimum operational burden and cost to the user. These objectives are achieved through weapon design which is system dependent. Therefore, it was determined that the advantages and disadvantages of modular technology must be analyzed by comparing a set of weapon system/warhead characteristics with weapon categories that group "like" types of weapons into specific strategic and tactical categories.

It has been found in the past that evaluation of generic systems for adaptation of modular technology has not been successful because of the uinique character of each system. To minimize the impact of this problem, the weapon system/warhead characteristics and weapon categories where chosen so as to provide a reasonably definitive weapon "type" without actually selecting a system either deployed or in development.

B. Approach

A single matrix was developed for a generalized list of weapon categories and an assessment was made concerning the impact of modularity on the weapon system/warhead characteristics. The following assessment factors were used:

- Very positive impact
- Some positive impact
- No change
- Netgative impact
- Not applicable

For the assessment, certain assumptions were made and additional factors considered in determining the impact of modularity on systems within the weapon categories developed. The systems were evaluated on the basis of the STS of like-type systems currently deployed. From this evaluation, which is qualitative rather than quantitative, three of the most promising candidates were selected for a more detailed utility analysis.

1. Weapon Categories. The widely-used lists of strategic and tactical weapon systems were grouped into like types of weapons in specific strategic and tactical categories. This was done to develop a workable matrix and to more readily identify categories of systems that might benefit from modular technology. The weapon categories used in the assessment are as follows:

Strategic

Surface-to-Surface Reentry Vehicle

- Fixed
- Mobile

Air-to-Surface

- Bomb
- Cruise Missile

Air-to-Air-Missile

Strategic Antiballestic Missile

Tactical

Surface-to-Surface

- Projectile
- Reentry Vehicle
- Cruise Missile
- Short Range Missile

Air-to-Surface

- Bomb
- Cruise Missile

Antisubmarine Warfare

- Cruise Missile
- Torpedo

Surface-to-Air-Missile

Air-to-Air Missile

Atomic Demolition Munition

2. Weapon System/Warhead Characteristics. The advantages and disadvantages of modular warhead technology were analyzed for each weapon category by comparing their impact on 34 specific weapon system/warhead characteristics. These competing weapon system/warhead characteristics are intended to establish a broad set of measures encompassing a relatively complete range of attributes desirable for nuclear weapons. These weapon system/warhead characteristics, and their definitions, are as follows:

Command and Control (C^2). Those features that limit warhead/warhead section use only to authorized personnel during circumstances specifically designated by proper authority. Features such as PAL and nonviolent disablement are specifically included.

Convertible Weapon (Dual Capability). A type of INC weapon that has both a nuclear capability when the SNM is emplaced and a valid conventional or chemical capability when the SNM is removed. (The fact that an HE plug, specific submunition, or chemical agent must be emplaced in the cavity intended for the INC, to attain a valid conventional/chemical capability in some designs, does not eliminate those designs from the convertible weapon category.) (Technical Publication, TP 4-1)

Cost. Actual or potential expenditure of dollars and SNM required to develop, produce, and support a weapon capability throughout its life.

Design Impact. The impact of nuclear design on the weapon system when considering the following design requirements.

- Primary only
- Primary with boost

DOE b(3) [redacted]

- Classification of WHB
- LLC considerations (the impact of modular technology on LLCs and changeout periods)

[redacted]

Desired Yield Range. The capability of modular technology to provide the required yield range.

Destruct (Violent). [redacted] (TP 4-1)

Disablement Nonviolent. Nuclear weapons disablement which, through the destruction or disassociation of one or more key warhead or warhead section or atomic projectile components, temporarily destroys a weapon's ability to be used in its intended mode or as an ADM. (TP 4-1)

Economy of Nuclear Material. Judicious design of active materials and designated special weapons materials whose possession and use are licensed and controlled by the Nuclear Regulatory Commission (NRC).

Explosive Ordnance Disposal (EOD). Activities involved in render-safe procedures and the safe removal of explosive ordnance.

INC Weapon. A nuclear weapon design concept whereby a nuclear-capable warhead can be converted from a nuclear-inert warhead to a live nuclear warhead by inserting a nuclear component. There are two general subclasses of INC warheads--convertible and nuclear-only.

Intrinsic Radiation. Nuclear radiation intrinsic to a weapon and emitted through the weapon's outer surface.

Maintenance. The actions necessary to maintain material in the desired state of operational readiness throughout its life cycle. Maintenance functions include checkout, servicing, crew augmentation, replacement, modification, and depot maintenance. (U.S.A. TRADOC PAM 71-12)

Mobility. The capability of the system to be easily moved in an operational environment.

Operational Effectiveness (OPS Effect). The capability of a system to perform the missions for which it was designed.

Personnel and Training. The number of personnel required and skills necessary to operate, maintain, and support the material system in its operational environment throughout its life cycle. Training includes the identification of personnel skills, training devices and aids, instructions, training documentation, and manuals required to support a material system. (U.S.A. TRADOC PAM 71-12)

Range. The impact of modular technology on system range.

Regulations and Directives. Official DOE, DoD, and armed services publications that establish or implement policies or procedures governing all phases of the life cycle of a nuclear weapon.

Reliability. The probability (without reference to countermeasures) that a weapon will detonate when it has been delivered to its target. (TP 4-1)

Risk (Technical). The degree of probability that a technical goal will be achievable in the system considered.

Safety (Munitions). The prevention of the initiation of energetic materials by normal or abnormal inputs of energy when initiation is not desired. This should include nuclear, HE, and plutonium-scatter safety.

Security. A condition that results from the establishment of measures which protect designated information, personnel, systems, components, and equipment against hostile persons, acts, or influences. (JCS PUB 1)

Stockpile Life. The period of time a warhead is available for employment by DoD.

Stockpile-to-Target Sequence Environment. The aggregate of all external conditions and influences affecting the weapon throughout the STS, including transportation, maintenance, storage, and launch. Factors included are temperature, humidity, and contaminants of the surrounding air; physical location and operating characteristics of the surrounding equipment and occupants; operational procedures such as acceleration, shock, vibration, heating effects, and radiation. (TP 4-1)

Support/Maintenance Facilities. Facilities to support the material system. Examples are: physical plant, real estate, portable buildings, concrete pads, revetments, roads, runways, housing, shops, depots, test sites, computers, training facilities, and storage areas.

Survivability. The capability of a system to withstand a manmade hostile environment without suffering abortive impairment of its ability to accomplish its designated mission. (TP 4-1)

Testing. The procedures and equipment required of DoD personnel (at any level) to certify the reliability of the system, or any of its components, in contrast with the more "conventional" nuclear system.

Transportation and Handling. The procedures, equipment, materials, and facilities needed for packing and crating; the use of reusable containers; supplies necessary to support packaging, preservation, storage handling, and/or transportation of prime equipment; support and test equipment needed; repair parts and supply support; personnel; technical data; publications; and facilities. (U.S.A. TRADOC PAM 71-12)

Vulnerability. The characteristics of a system that cause it to suffer a definite degradation as a result of having been subjected to a certain level of effects in an unnatural (manmade) hostile environment. (TP 4-1)

3. Assumptions and Additional Considerations. In development and assessment of the matrix of potential modular applications, certain assumptions and considerations were applied.

(1) Evaluations were made on the basis of providing something better with modular technology than currently exists in a standard nuclear warhead design.

(2) Certain warhead characteristics were weighed more heavily than others in this assessment. These were

design impact

operational effectiveness

safety

security

survivability

transportation and handling

(3) It was assumed that modular design technology would use relatively higher amounts of SNM; therefore, economy of SNM would reflect a "negative" in most generic system considerations.

(4) Generally, a reduction in reliability can be expected in most modular technology designs and was so reflected for all generic system categories.

(5) Deployment of modular systems would necessitate a restructuring of current regulations and directives addressing nuclear weapon storage, transportation, and handling, and therefore reflect a negative impact.

C. Assessment

1. General. Evaluation of the matrix found in Fig. IV-1 indicates that the strongest contenders for modular technology are tactical systems. Those tactical systems that appear to be the most favorable modular candidates but still allow adaptation to other tactical uses include the following:

(1) Land-launched tactical missile/cruise missile (SSM/SAM), either convertible or nuclear-only

(2) Sea-launched tactical missile/cruise missile (SSM), again either convertible or nuclear-only

(3) Air-launched tactical bomb or air-to-surface missile with a nuclear-only capability

These three candidates can cover a wide variation of STS environments and system variations. Other systems identified for future consideration in modular technology applications include the strategic mobile missile system (AICBM), an air-to-air missile (for strategic or tactical use), and several tactical-only systems.

2. Specific Assessment Considerations. A number of observations can be made in reviewing the matrix and resulting evaluation.

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[redacted]

Fig. IV-1. Assessment matrix.

(1) Certain characteristics reflect strong support for modularity technology in all weapon categories. These include

destruct (violent)

disable (nonviolent)

explosive ordnance disposal (EOD)

These three categories encompass security measures designed to ensure against theft or unauthorized use of nuclear weapons. By separation of components, the modular concept provides inherent improvement in security during peacetime and in crisis against the threat of theft or unintended use. Standard nuclear weapons are not generally amenable to such methods of use denial except through design and operational measures that are relatively cumbersome in comparison to component separation.

(2) Those tactical systems that appeared to be the most favorable candiates for application of modular technology reflecting strong support in the following additional warhead characteristic categories.

command and control

yield range

mobility

safety

security

small volume/lightweight

stockpile-to-target sequence environment

support/maintenance facilities

survivability

transportation and handling

vulnerability

design impact (primary and boost)

(3) [redacted]

(4) Some tactical candidates scored very well but were not selected.

Projectile. [redacted] it was considered improbable that a new projectile would be considered for development in the near term.

Torpedo. A new nuclear torpedo has been under development consideration for several years but is still in question. There is a good possibility that modular technology would have application for the selected candidate systems, either a new torpedo or in retrofit of [redacted] torpedoes.

Atomic Demolition Munition. The development of a new ADM is questionable at this time. [redacted]

Air-to-Air Missile. The requirement here could have Air Force and Navy applications but does not appear to have the urgency that the selected candidates reflect in meeting projected DoD needs. This would be a good follow-on candidate for modularity consideration.

(5) Within the strategic categories, the mobile ICBM [surface-to-surface reentry vehicle (RV)] appeared to be a reasonable candidate for modularity, but in view of the political and operational problems associated with mobile strategic systems in the CONUS at this time, it was viewed as another good follow-on candidate.

CHAPTER V

UTILITY ANALYSIS

A. Introduction

This chapter examines the utility of modular nuclear warheads within the context of three generic candidates, one system for each of the military services. What we have attempted to do is address the advantages and disadvantages offered by these kinds of warheads. We recognize that hardware is only one aspect of the military equation; the conclusions we reach here must be tempered by the existing political and military doctrinal environment and especially by the current administrative framework. Many factors, including the element of political and military strategy, leadership, personnel training, application of the principles of war, and modus operandi of the STS, are major parameters that ultimately drive the real worth of these systems whether in peacetime deterrence or wartime application. Admittedly, the focus is within the European environment where the survivability of our nuclear forces has been and continues to be severely questioned. We see that modular nuclear weapons potentially offer a substantial increase in survivability, particularly for the Army and Air Force candidates. But turning away from our potentially most important war area to those areas of the world where wars may be more likely, a force of Army or Navy convertible systems offers tremendous flexibility to respond conventionally and to deter nuclear responses within special theaters. Several advantages, including the all-important increase in survivability, also accrue to the Air Force candidate modular system that is dedicated to the nuclear role.

Let no one doubt that obstacles must be overcome to field successfully these kinds of warheads. The technical challenges, however, are not high risk. Reliable and safe modular warheads can be built using present design and engineering capabilities. It is their impact upon the well-established administrative, security, and surety community that involves major ramifications. If modular systems are treated as "business as usual," then only safety advantages result from the separation of plutonium from the HE during most of a warhead's life. Instead, the logistic and regulatory community should modify the peacetime logistic system in order to realize a survivable nuclear system, even with the probability of an increase in costs. Increases in survivability should be the primary reason for developing, producing, and deploying modular nuclear warheads. Though the benefits of having safer warheads are of great importance, we realize that modern standard warheads have an unblemished safety record regarding accidental nuclear detonation;

DOD

The real benefits in safety improvements lie in allowing changes in the transportation and storage of nuclear weapons that, in turn allow greater dispersion and enhanced survivability. Personnel training needs high emphasis, not only in the obvious mechanics of inserting the nuclear component into the WHB or in installing additional submunitions in a field environment, but also in the total tactics of moving from unit kasern to field locations, or in deploying to collocated Air Force bases, or in changing missile capabilities afloat, as the service case may be.

Beyond the scope of this analysis are several important areas that will have an impact on modular warhead deployments. We do not examine the arms control ramifications which are always of concern to military planners when trying to field new hardware. We also do not examine the strategic and tactical doctrine under which the Armed Forces operate. Both of these factors can affect the ultimate utility of modular weapon systems. In this utility analysis, we assume away the arms control problem and accept the major tenets of the present doctrinal framework (such as flexible response) in applying our logic. We do modify some of the underlying tenets to exploit the utility of modular weapons.

Other political and military considerations, more microscopic in nature, do require treatment. In this analysis, we treat these considerations under a generally favorable environment in order to determine the advantages and disadvantages of modular systems.

We initially describe the generic weapon systems, then take the characteristics used in Chapter IV to identify potential modular applications and examine them through a taxonomical structure consisting of sections on safety, security, survivability, operational effectiveness, logistics, and costs. Relative utility numbers are generated for each section and then aggregated to try to quantify the advantages and disadvantages; the reader can accept or reject this tool yet still support the findings in the summary section which ends the chapter. The conclusions and recommendations that emerge from this utility analysis are given in Chapter VII.

B. Weapon Description and Stockpile-to-Launch-Sequence (SLS) Differences

1. General. The approach of this section is to describe initially the candidate modular warheads, then to describe the three modular weapon candidates, and finally to compare their SLSs with the baseline systems. All three candidates are low-quantity buy, high-value munitions.

2. Candidate Modular Warheads. Two warhead candidates are chosen to satisfy potential tactical yield requirements. We vastly prefer the first candidate because of its smaller size, lower weight, and simple design.

a. Warhead Candidates #1. [redacted] The second component is the WHB. For the nuclear application, [redacted] Convertible weapons would also contain additional volume in the WHB for conventional munitions, either sub or unitary. Further investigations in the areas of costs, range, safety, and reliability are needed to determine if a conventional HE filler plug for the cavity in the WHB is warranted for conventional missions and if the conventional munitions normally in the WHB should be removed before firing a nuclear mission. The WHB body would not contain RD. [redacted]

[redacted]

[redacted] The INC would contain the nuclear materials, primary, secondary, IHE, and warhead electrical system. Its main disadvantage is in the large size and heavy weight of the INC. [redacted]

c. Discussion. These modular warhead designs present some technical development and production difficulties, especially in trying to ensure that the WHB contains no RD. Some low risks face the warhead designers. The biggest challenge is to design and produce a highly reliable system that must undergo field insertion. Probably the major challenge is the successful interconnect of the WHD electrical system with the missile fuzing system. Of course present day Lance and Pershing warheads are field mated to their missiles and they possess high relability. Nevertheless, the INC must undergo, in the field, an operation--the mating of explosives and the pit--that is normally done at a DOE plant. Though reliability may be less, designers are confident of providing a highly reliable system by using proper technology and assuming suitable user training in adverse environments, such as sandy southwest Asia or cold and damp northwest Asia.

3. Army Requirements. The Army missions for the analysis are

- Conventional fires to [redacted] primarily by using submunitions (and perhaps a chemical round) against armored and other tactical vehicles
- Nuclear fires to do the same mission
- Conventional air-defense at medium to high altitude, possibly tactical nuclear ABM defense, and back-up SSM nuclear fires

Current baseline systems are the Lance with conventional warhead for the first mission, the [redacted] nuclear warhead for the second, and the Improved Hawk and Hercules for parts of the last mission. The Lance suffers from several shortcomings: it is manpower inefficient, range-limited, old and increasingly difficult to maintain, and relatively inaccurate and unresponsive because of its time-consuming warhead mating operation. The Improved Hawk, though still one of the best medium-range air-defense systems in the world, is being replaced by the Patriot. The Patriot will also replace the very old Nike-Hercules. The Hawk and the Patriot are not fielded with a nuclear capability.

MC

[redacted] The AD batteries would generally use a unitary conventional warhead, but these units would also possess a number of missiles that could deliver back-up surface-to-surface nuclear and/or tactical nuclear antiballistic missile (ABM) fires. The field artillery would be dedicated to the ground role, with the capability to deliver nuclear warheads or conventional submunitions (and possibly chemicals). Whether or not these missiles should be convertible in the AD role (unitary conventional or nuclear) and convertible in the field artillery (FA) role (submunition or nuclear) depends upon cost and operational effectiveness trade-offs. We propose a dual-capable missile, however, for two reasons: (1) the greater economics from developing and producing the missile in a joint program and (2) increased survivability through deployment of back-up INCs and SSM missiles to AD units.

Figure V-1 shows the SLSs in peacetime. Fig. V-2 shows these sequences in alert or during wartime.

What are the major differences between the baseline systems and the modular candidate within their SLSs? Table V-I succinctly shows the main differences.

DOD

[redacted]

DOD

[redacted]

We have stressed the importance of a favorable regulatory and administrative environment upon the potential utility of the modular candidates. Except for the case of safety where modular weapons are inherently more safe than standard nuclear weapons, a favorable environment is necessary to realize fully the advantages of modular weapons and to minimize the potential disadvantages. Environment is used here in the broadest sense of the word and includes major external factors--political, economic, technical, administrative, or military--that may have an impact upon the three modular candidates.

Combining the advantages and disadvantages intuitively into a decision to proceed or not to proceed with development and engineering is difficult. We provide a simple scheme for aggregating the advantages/disadvantages into an overall quantitative merit value. We then use this scheme to present our quantitative numbers as a guide (see tables at the end of each subsection). The steps in the scheme are:

(1) Assign a number from zero to three based upon relative evaluation of the value/importance (VI) of each subarea and major area.

- 0: Unimportant
- 1: Some importance
- 2: Very important
- 3: Extremely important

(2) Evaluate the utility/worth (U) of the modular warhead as compared to that of the the baseline system in meeting the subarea's requirements.

- -1.0: Much inferior to baseline
- -0.5: Inferior to baseline
- 0: Same as baseline
- +0.1: Insignificantly better than baseline
- +0.2: Slightly better than baseline
- +0.4: Somewhat better than baseline
- +0.5: Better than baseline
- +0.7: Substantially better than baseline
- +1.0: Much better than baseline

(3) As a conclusion to each major area (for example Safety) discussion, calculate the average merit for all subareas (N in quantity) within that major area.

(4) Repeat step 3, above, to aggregate all major areas into a final worth.

$$\frac{\sum_{i=1}^{N}\left(VI_i \times U_i\right)}{\sum_{i=1}^{N} VI_i}$$

D. Safety

Safety is the prevention of the initiation of energetic materials by normal or abnormal inputs of energy when initiation is not desired. We distinguish between two types of safety: (1) nuclear detonation safety where an inadvertent detonation gives a nuclear yield in excess of four pounds HE equivalent and (2) plutonium-scatter safety where detonation of the HE results in dispersion of plutonium. Even in an unfavorable regulatory and administrative environment, modular warheads engender increased safety levels.

1. Nuclear Detonation

a. Statement

Separation of explosives from nuclear material inherently increases nuclear detonation safety. (All three candidates)

- Before insertion, modular warheads are safer than the baseline nuclear warheads.
- After insertion, modular warheads are as safe as baseline nuclear warheads.

b. Discussion

Modern nuclear weapons are safe from accidental nuclear detonation, especially those containing IHEs--the U.S. has a perfect record. However, modular warheads are safer before insertion because the INC is physically separated from the HE. The probability of an accidental nuclear yield is zero. After the INC is inserted into the WHB, the modular warhead candidates are as safe as the baseline warheads and can meet the stringent military requirements. INCs would incorporate modern safety features such as weak-link/strong-link circuits and would be stored in safe secure containers. The Army and Air Force candidates would use IHE; the Navy would use DESTEX for their convertible system.

As an example for the first merit estimation and to indicate our logic, we rate the VI of nuclear detonation safety as 3 (extremely important). Compared to the baseline systems which already afford high nuclear detonation safety, we assign a U of +0.2 (slightly better than baseline).

c. Merit Estimation

Candidate	VI	U	VI x U
A, N, AF	3	+0.2	+0.6

2. Plutonium-Dispersal

a. Statement

Accidents involve lower probabilities of plutonium dispersal. (All three candidates)

b. Discussion.

The two accidents at Thule, Greenland; and Palomares, Spain, in the 1960's required significant cleanup operations and caused much greater political results (such as changes to B-52 alert operations). Future accidents that cause plutonium scatter, especially if in populated areas, could create tremendous problems. The use of IHE for some of our stockpiled weapons has greatly reduced some of these concerns. Nevertheless, the sheer number of nuclear weapon movements leaves the door open for future plutonium dispersal accidents. An accident involving the movement of a WHB (less INC) would not disperse plutonium (it has none) nor should it be called a nuclear weapon accident or incident. An accident involving an INC would have a much lower probability of plutonium dispersal because of substantially reduced HEs. This is because the IHE used in the INC is minimal. Also, the secure container could generally be stronger than the shipping containers and canisters of the baseline systems, meaning less chance for rupture.

c. Merit Estimation

Candidate	VI	U	VI x U
A, N, AF	3	+0.4	+1.2

3. Intrinsic Radiation

a. Statement

Intrinsic radiation concerns can be lessened by storing INCs in shielded containers. (Navy)

Intrinsic radiation concerns are increased because of greater amounts of nuclear materials in the INCs if shielding is not adequate. (Navy)

b. Discussion

The proximity between crew living and working quarters aboard Navy ships and particularly submarines is a real health concern. In some cases aboard submarines, the crews "live" on top of the nuclear weapons. Intrinsic radiation from nuclear warheads might subject crews to levels above that permitted by medical regulations. An all-up nuclear canistered Harpoon is not easily shielded or stored away from crews; a small INC is. Already shielded by its container, additional shielding can be easily provided to the INC because of its small volume. The second concern deals with exposures when handling the INC out of its container. The time intervals are so short that the radiation effect is minimal. Finally, intrinsic radiation concerns are of much smaller magnitude in the Army and Air Force considerations because of personnel separation from the nuclear munition.

c. Merit Estimation

Candidate	VI	U	VI x U
N	2	+1	+2
A, AF	0	+1	0

4. Total and Average Merit Under Safety.

Candidate	Total Merit	Average Merit
A	+1.8	+0.3 (somewhat better than baseline)
N	+3.8	+0.5 (better than baseline)
AF	+1.8	+0.3 (somewhat better than baseline)

E. Security

We define security as a condition that results from the establishment of measures to protect designated information, personnel, systems, components, and equipment against hostile persons, acts, or influences. Several technical and operational advantages accrue to modular warheads.

1. Command and Control

a. Statement

Command and control requirements are now on components that are individually unable to produce a nuclear yield. (All three candidates)

b. Discussion

Command and control is defined as those features that limit warhead use only to authorized personnel during circumstances specifically designated by proper authority. Baseline systems are protected by PALs and are stored in special nuclear storage areas. One of the reasons for this is the fact that the baseline nuclear round is a full-up nuclear round. An INC in its secure storage container (with PAL, etc.) and the WHB are not full-up rounds by themselves.

c. Merit Estimation

Candidate	VI	U	VI x U
A, N, AF	2	+0.7	+1.4

2. Nonviolent Disablement

a. Statement

Nonviolent disablement measures are more compatible with a secure container than a full-up munition or missile. (All three candidates)

b. Discussion

DOD
DOE
b(3)

c. Merit Estimation

Candidate	VI	U	VI x U
A, N, AF	1	+0.2	+0.2

3. Emergency Destruct

a. Statement

Emergency destruct of nuclear capability and design information is more readily conducted within the secure container. (All three candidates)

b. Discussion

DOE

the greater quantities of HE make the probability of plutonium dispersal greater than zero. However, design information may still be inferred. The modular candidates would have their INCs stored in a command-destruct secure container. It would be so designed as to contain the destruction of the INC, maintain its integrity, and yet eliminate design information.

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c. Merit Estimation

Candidate	VI	U	VI x U
A, N, AF	2	+0.7	+1.4

4. Safe Secure Container

a. Statement

The safe secure container is virtually secure and reduces concerns for HE protection. (All three candidates)

b. Discussion

DOE b(3)

DOE b(3) DOD

c. Merit Estimation

Candidate	VI	U	VI x U
A, N, AF	1	+1	+1

5. Vulnerability to Theft

a. Statement

DOE b(3) DOD

b. Discussion

The INC within its container, while not portable by a single man, is certainly easier to move than a missile, W81 or W70 warhead, or B57 or B61 bomb. This particularly may apply to the Army candidate and to a lesser extent the Air Force and the Navy candidates, according to the number of sites and potential exposure to security threats.

DOD DOE (b)(3)

This may do wonders for security but it has a negative impact upon operational effectiveness and survivability.

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c. Merit Estimation

Candidate	VI	U	VI x U
A	2	-0.4	-0.8
N	1	-0.2	-0.2
AF	2	-0.4	-0.8

6. Peacetime Dispersal

a. Statement

Peacetime dispersal to using units (Army) or deployment during crises/hostilities to collocated air bases or strips (Air Force) for increased survivability means:

- Exposure to more personnel
- Storage at less secure areas than the baseline unless storage wells or exportable shelters are provided

b. Discussion

By personnel, we mean authorized and unauthorized military plus civilians.

Storage aboard Navy ships and submarines would also be modified to account for shielding of the INC containers and storage away from the crew. The negative impact of dispersal upon Naval security should be very small.

c. Merit Estimation

Candidate	VI	U	VI x U
A	2	-0.4	-0.8
AF	2	-0.4	-0.8
N	1	-0.1	-0.1

7. Total and Average Merit Under Security

Candidate	Total Merit	Average Merit
A	+2.4	+0.2 (slightly better than baseline)
N	+3.7	+0.5 (better than baseline)
AF	+2.4	+0.2 (slightly better than baseline)

F. Survivability

1. Enemy Targeting

a. Statement

b. Discussion

[redacted]

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